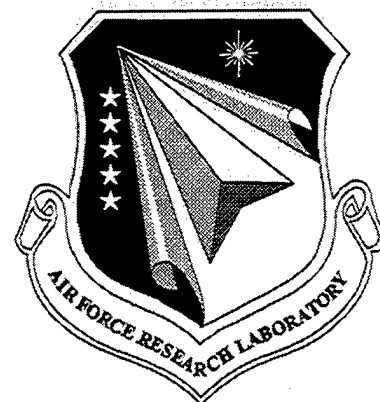


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**AGING AIRCRAFT STRUCTURES
DATABASE**



R. Perez

**The Boeing Company
St. Louis, Missouri**

MARCH 1998

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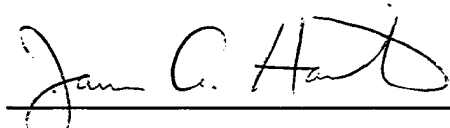
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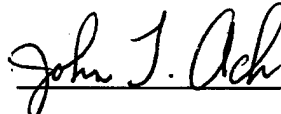
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13. ABSTRACT (Maximum 200 words) This report summarizes the work performed by the Boeing Company to develop an aging aircraft structures database to be used to aid in the verification of structural integrity analysis of aircraft structures. Sample data were collected for the C-30, EC-135, C-141, and F-15 aircraft in the areas of fatigue, corrosion, and structural repair. A user-friendly database was developed using Microsoft Visual Basic ®, which can be accessed by other windows based structural analysis software. The report also summarizes work performed to link the database to the existing Air Force crack growth life prediction program, AFGROW.				
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1. Introduction

The main objective of the Aging Aircraft Structural Database (AASD) is the storage of detailed descriptions of fatigue, corrosion and associated repairs in USAF aircraft. The data structure within AASD was designed to allow for flexibility in the type of data that can be stored. This flexibility was intended to permit data across the fleet to be stored. For example, users can enter different nomenclature applicable to the various aircraft types.

As data is gathered in the future and stored in AASD, this information can be provided to the research and development community. Access to actual aircraft data will facilitate the development of structural integrity analysis tools needed to model the damage observed. These tools can then be verified with actual data.

One of the main features of AASD is its link with the AFGROW crack growth analysis software [1-1]. Data stored in AASD can be rapidly downloaded as input to an AFGROW crack growth analysis. As each structural analysis is completed, AASD can be used to store photographs and information describing the problems solved. These library of analysis cases can be a depository of case histories and an important source of lessons learned.

Other databases have been developed for storing structural information for specific aircraft at USAF Air Logistic Centers (ALC). An example is the Aircraft Information Retrieval System (AIRS) developed for the F-15 [1-2]. A key feature of this system is its link to maintenance activities associated with the aircraft. As maintenance is performed, AIRS provides a method for recording the damage observed and the repairs performed. "F-15 Inspection Tracking Record" paper forms filled by the inspectors during maintenance are scanned and the information stored. The C-130 also has a similar AIRS database in place [1-3].

The On-Site Collating and Recording (OSCAR) system developed for the C-141 provides a method for directly entering the data into laptop computers during inspections [1-4]. OSCAR uses a Windows based database to record the damage found, location, repair configuration, inspection date, flight hours at inspection, inspection interval, and pictures. Another system for the C-141 is Automated Readiness Integrated Engineering System (ARIES) [1-5]. ARIES covers individual aircraft tracking, aircraft inspections, supportability and repairs tracking.

Another database developed for the C/KC-135 is the Stratotanker Condition Analysis and Logistics Evaluation (SCALE) [1-6]. SCALE provides an easy to use maintenance data collection system in which data is selected by intensive use of aircraft part graphics.

AASD is not meant to compete with the above maintenance focused databases used at USAF ALC's. The other systems contain a level of detail required for maintenance record keeping and fleet tracking. AASD only stores data needed for structural integrity analysis. ALC databases are typically associated with specific aircraft, while AASD

provides a location for storing data for military aircraft throughout the fleet. Because of security reasons, maintenance data in the other systems has limited access. AASD is intended for wide government and industry access.

Representative data has been included in the database for the following aircraft: C-130, EC-135, C-141, and F-15. The purpose of including this data in the first version of AASD is to illustrate a wide variety of fatigue, corrosion and repair cases within the aging fleet. Also, the data serves as an example of how data can be stored in the database for a wide variety of aircraft. As users collect additional data, the present data can serve as a model for data storage formats.

2. Aging Aircraft Data

2.1 Sources of Data

Aging aircraft data is fragmented and distributed over a wide variety of locations. These range from electronic systems to individual reports documenting specific structural evaluations. As part of the AASD development effort, representative aging aircraft data was collected for the C-130, EC-135, C-141, and F-15 aircraft. The existing electronic maintenance databases such as AIRS were consulted first to obtain data. The electronic nature of these systems offered the possibility of rapid access to information for a large number of aircraft. Although AIRS systems contain extensive aircraft information, these systems offered very limited fatigue and corrosion data [2.1-1]. A data entry may mention that a crack was repaired, but in most cases crack dimensions, orientation or location are not given. Maintenance technicians at the flying unit or at the depot are requested to record the information on a datasheet. However, this part of the maintenance action is often neglected.

The data included in AASD was collected from individual reports describing measured fatigue cracks and corrosion in detail. However, these sources had other limitations. For example, material and spectrum data were seldom accessible. Discussions of the information sources are described in the following sections.

2.1.1 C-130

The C-130 AIRS was one of the first sources accessed to obtain aging aircraft information. However, as mentioned earlier, AIRS, along with other electronic databases used at ALC's, did not offer the level of data resolution needed for AASD. These systems depend on maintenance personnel for the crack and corrosion measurements, and the recording of this data is not a high priority.

The main source of data for the C-130 was obtained from detailed structural analysis reports published by WR-ALC [2.1.1-1 thru 7]. The outboard engine aft truss mount upper tang illustrated in Figure 2-1 was one of the locations analyzed.

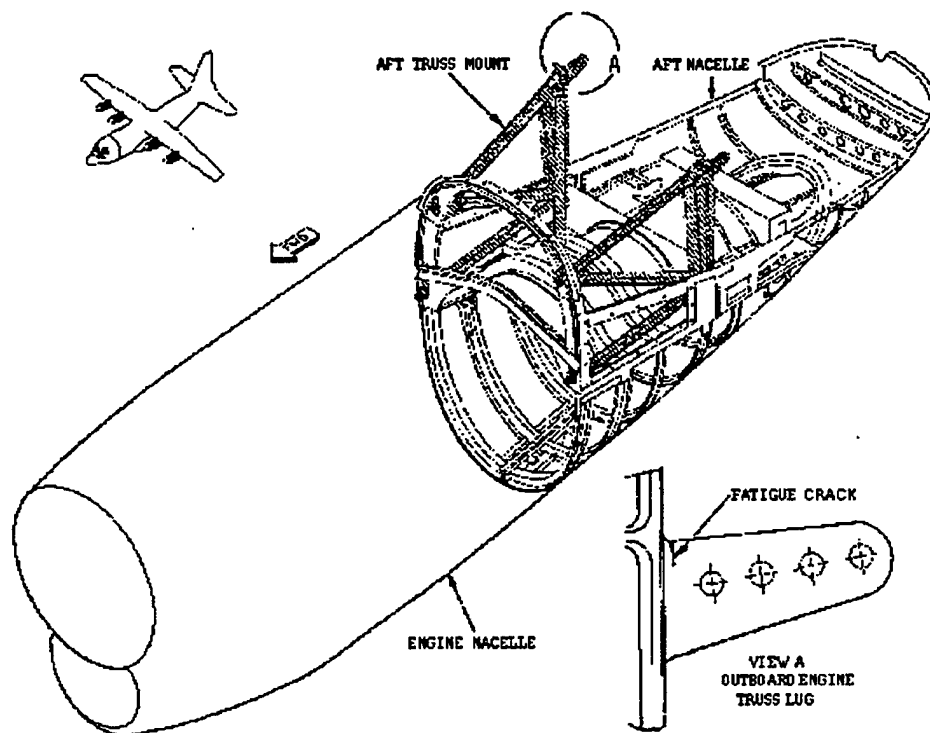


Figure 2-1 - Engine Aft Truss Mount Upper Tang Crack Location

Additional fatigue crack data was provided by Waldbusser [2.1.1-8] for the wing skins in the vicinity of W.S. 220 (Figure 2-2). Corrosion information for the C-130 was also collected from Reference [2.1.1-9]. Examples of corrosion data in this document include stress corrosion cracks experienced at the wing joint corner fittings and surface corrosion in the main landing gear frames.

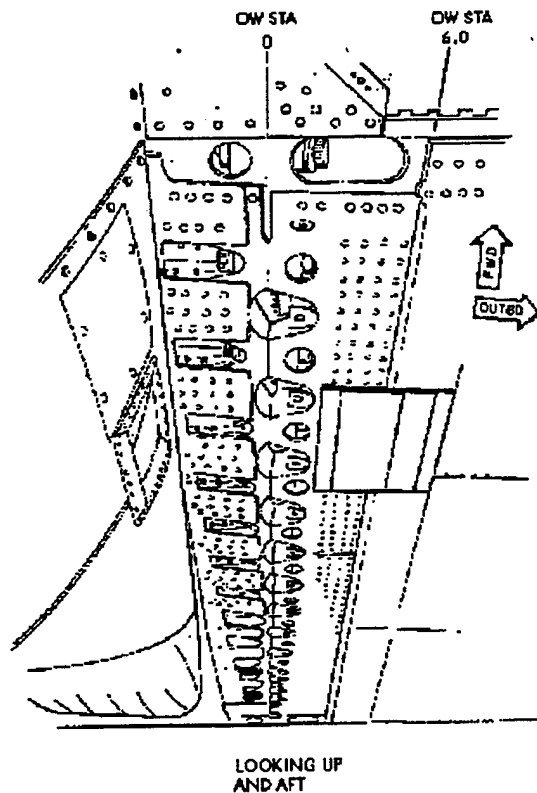


Figure 2-2 – C-130 W.S. 220 Area

The majority of the repair information for the C-130 was collected from Reference [2.1.1-10]. One example is the aft fuselage sloping longeron illustrated in Figure 2-3. Corrosion in this component is repaired with grindouts and a 4130 steel c-cross section repair member as illustrated in Figure 2-4. Supplemental data for the C-130 was obtained from References [2.1.1-11 thru 13].

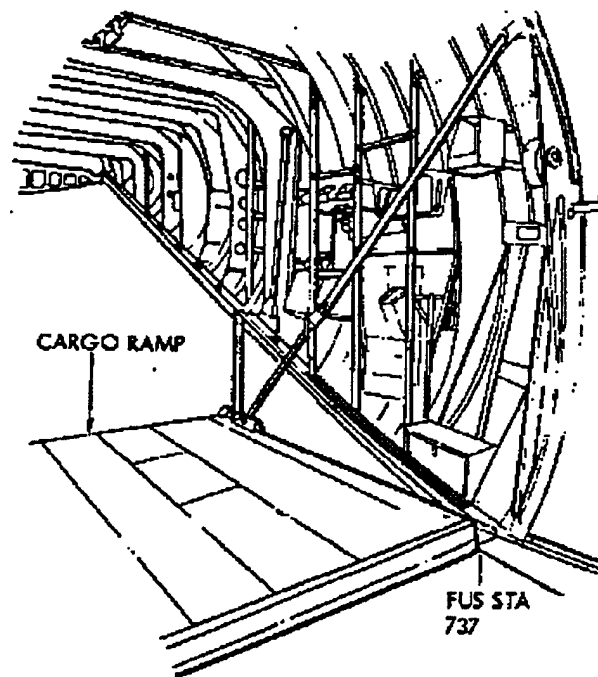


Figure 2-3 – C-130 Sloping Longeron

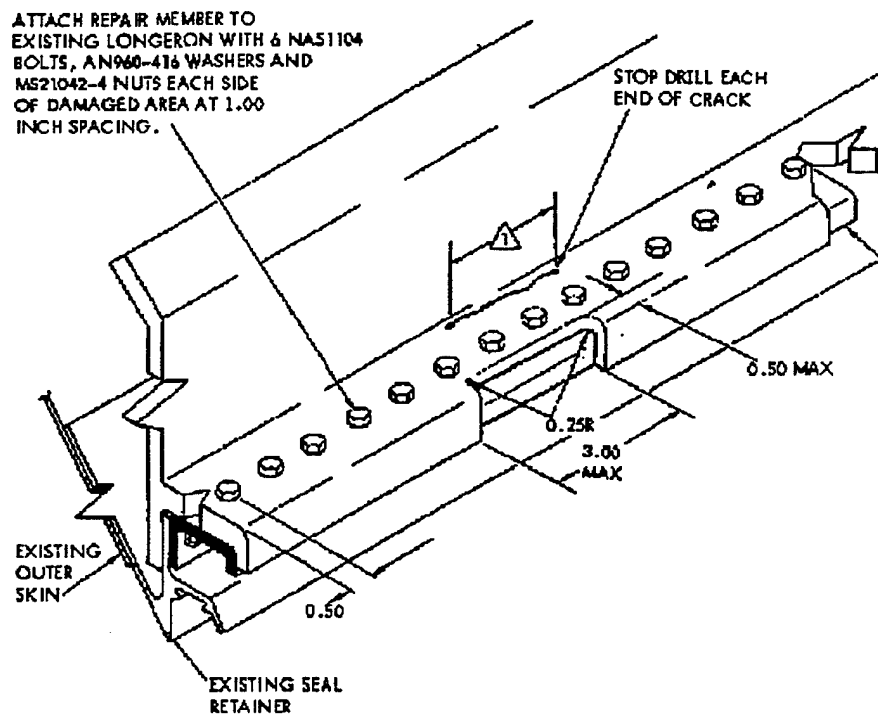


Figure 2-4 – C-130 Sloping Longeron Repair

2.1.2 EC-135

The main source of data for the EC-135 was obtained from a series of reports documenting the inspections performed on the disassembled EC-135H aircraft (tail number 61-0291) [2.1.2-1 thru 5]. This aircraft was originally a KC-135A that became operational on 13 February 1962 and was assigned to Mindenhall AB, England. In the late 60's it was converted to an EC-135 Airborne Command Post. The aircraft was retired on 6 June 1991 after completing 29 years of service. It had accumulated 16,521 flight hours.

As part of the disassembly effort, 293 sections were cut from the aircraft at Davis Montham AFB and shipped to Boeing in Wichita, Kansas. At Boeing, the sections were photographed, disassembled, inspected and measurements of cracks and corrosion were documented. From this large set of documentation, data was selected for inclusion in AASD. The selection covered a wide variety of components throughout the airframe in order to demonstrate AASD's capacity to accept different data. Figure 2-5 illustrates some of the locations in the forward fuselage from which data is recorded in AASD.

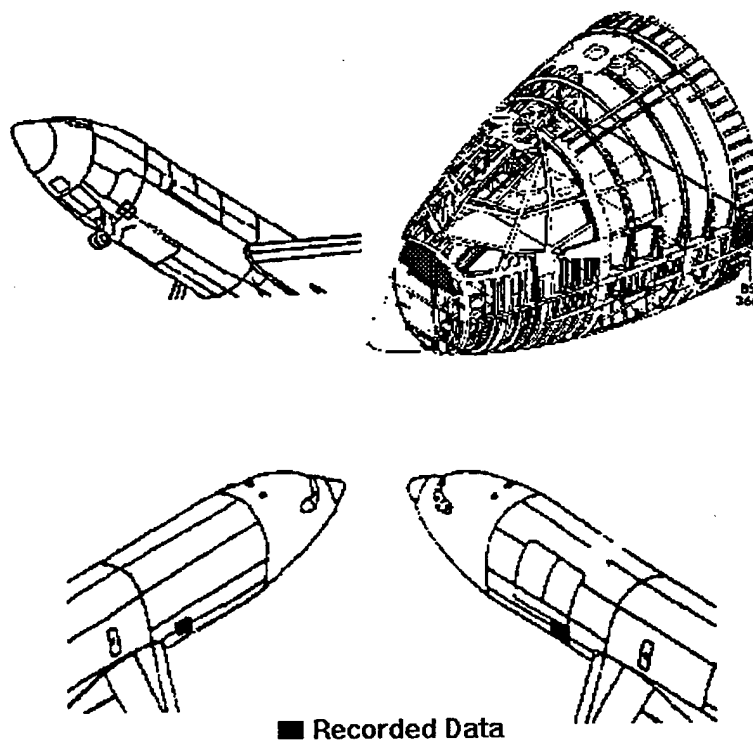


Figure 2-5 – Selected EC-135 Forward Fuselage Locations

2.1.3 C-141

The C-141 AIRS system and other ALC electronic databases were considered as potential source of data for AASD. However, a significant amount of data was found associated with the wing lower panel weep holes [2.1.3-1 thru 4]. Detailed measurements were made and recorded during the inspection and repair of weep hole cracks found in the C-141. Because of the limited resolution of damage data in AIRS the weep hole data was used as the representative data in AASD.

2.1.4 F-15

The F-15 AIRS was also evaluated as a possible source of data, but this system was again limited by the resolution of the damage information recorded by the maintenance personnel. F-15 data is also limited by the fact that this aircraft has suffered from relatively little fatigue cracking. One location where cracks have occurred is in the wing outboard front spar illustrated in Figure 2-6 [2.1.4-1]. Cracks have developed in A/B/C/D models at a wire bundle routing hole. Repairs have been designed for these aircraft [2.1.4-2] and the location has been redesigned in the F-15E. Thirty-four crack size measurements were stored in AASD. The load spectrum for this location was obtained from reference [2.1.4-3].

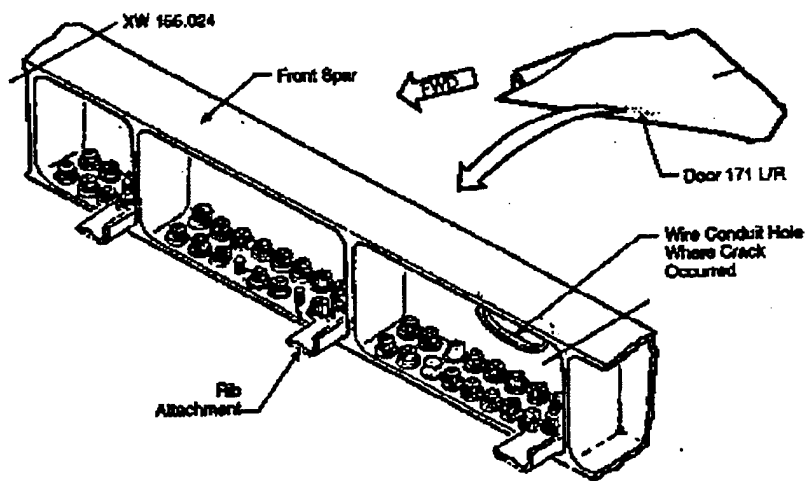


Figure 2-6 - F-15 Front Spar Crack Location

2.2 Parameters

The parameters included in the database were selected in order to satisfy two requirements: (1) Provide an adequate description of fatigue, corrosion and repair cases. (2) Provide the input data needed to run the AFGROW crack growth software. The second requirement is satisfied with three specific sets of data: material data, geometrical description of the part and the fatigue crack, and load spectrum. The material data is typically in the form of a da/dN vs. stress intensity factor curve. The geometric data covers the pertinent part dimensions of thickness, width, and hole diameter needed for the analysis, and also includes crack dimensions. The load spectrum describes the load history.

The first requirement is satisfied with more general parameters documenting the location of the damage on a particular aircraft, for example. The other databases consulted during the study provided models for organizing aging aircraft information. The following parameters were selected to represent the fatigue data (the symbol * next to a parameter indicates that the data is needed by AFGROW):

- Aircraft Type (C-130, EC-135, etc.)
- Aircraft Zone (wing, aft fuselage, etc.)
- Part Name
- Part Number
- Part Material *
- Material File Name *
- Specific Aircraft Tail Number
- Actual Flight Hours (when the inspection was performed)
- Equivalent Flight Hours (when the inspection was performed)
- Flight Cycles
- Age
- Fatigue Feature Name
- Source of Data or Reference
- Hole Number
- Hole Diameter *
- Part Thickness *
- Part Effective Width *
- Crack Orientation
- Description of Crack Geometry or Configuration *
- Crack Dimensions *
- Load Spectrum File Name *

The following parameters were selected to represent the corrosion data:

- Aircraft Type (C-130, EC-135, etc.)
- Aircraft Zone (wing, aft fuselage, etc.)
- Part Name

Part Number
Part Material
Specific Aircraft Tail Number
Actual Flight Hours (when the inspection was performed)
Equivalent Flight Hours (when the inspection was performed)
Flight Cycles
Age
Corrosion Feature Name
Source of Data or Reference
Part Thickness
Surface Description
Corrosion Area
Corrosion Minimum Depth
Corrosion Maximum Depth

Finally, the following parameters were selected to represent the repair data:

Aircraft Type (C-130, EC-135, etc.)
Aircraft Zone (wing, aft fuselage, etc.)
Part Name
Part Number
Part Material
Specific Aircraft Tail Number
Actual Flight Hours (when the inspection was performed)
Equivalent Flight Hours (when the inspection was performed)
Flight Cycles
Age
Corrosion Feature Name
Source of Data or Reference
Description of the Repair

3. Database Organization

The database user operations have been divided into two major sections. The first section, "AASD Editor", allows users to enter new data into the database. The second section, known as the "AASD Viewer", permits users to see the information stored in the system. Once in AASD Viewer the user can also plot and analyze the data with Microsoft Excel directly from the system.

3.1 AASD Viewer Operation

The database has been organized in a hierarchical format that allows a user to go from the aircraft down to the specific damage feature information (Figure 3-1). After selecting an aircraft type from the list in AASD Viewer, and the zone of interest within the aircraft, the user picks the part where data is needed. The user can then select a specific aircraft, identified by tail number, where damage information may be available. Finally, the damage feature information associated with the above selections is accessed. Damage features can include fatigue, corrosion, or repair information.

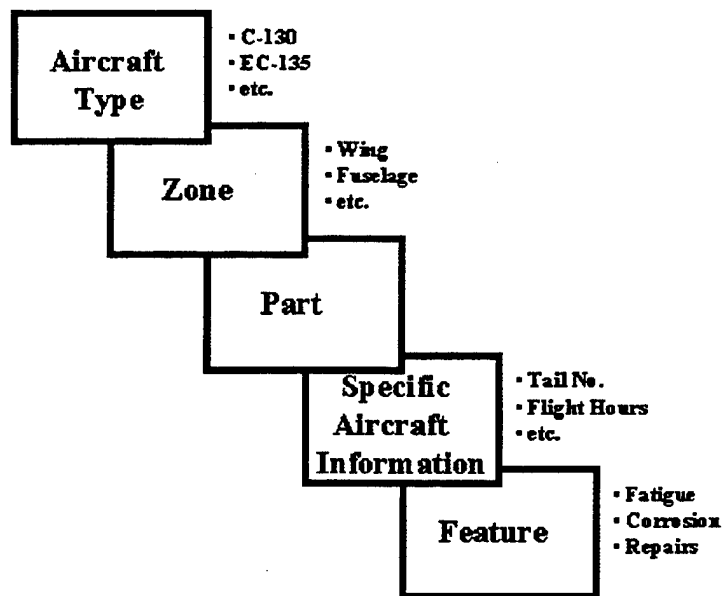


Figure 3-1 – Hierarchical AASD Database Organization

After the AASD Viewer is accessed, the main window is activated. At this time, this window allows the user to perform two operations. First, the user can click on the "Material Data" button to see a list of files stored in the materials folder within the database system. Clicking on a particular file permits the user to see a quick plot of the da/dN vs. Stress Intensity Factor curves for a particular material. If a user wishes to see a

different file, clicking on the "Different Material" button allows him to do so. The curves can also be displayed in Microsoft Excel by clicking on the "Data to Excel" button. Excel presents the data in three sheets. The first ("Data") contains the tabulated data, the second ("Material") displays the curves, and the third ("Internal") contains the data and parameters used to generate the curves. Material file formats are described in Section 3.4.

The second operation that the user can perform after opening the AASD main window is the selection of a type of aircraft. This is achieved by clicking on the pull down list under "Aircraft Type" and then selecting an aircraft. A photo or schematic representing the aircraft is then displayed.

Next, the selection of an aircraft zone can be achieved by clicking on the aircraft figure within the desired zone or by selecting from the pull down list of available zones. The list is useful when viewing data for an aircraft type for the first time or when a user is not familiar with the aircraft. Additional zones for an aircraft can be added using AASD Editor.

After a zone is selected, a drawing or a photo is displayed typically indicating what parts within the zone contain damage information. The next step is to select the part of interest within the zone. This can be achieved by clicking on the zone figure within the desired part or by selecting from the pull down list of available parts. As mentioned earlier this type of list is useful when viewing data for an aircraft zone for the first time or when a user is not familiar with the aircraft. Additional parts can be added using AASD Editor.

After a part is selected, a drawing or a photo of the part is displayed. The next step is to select a specific aircraft from the pull down list for which damage has been measured. The aircraft are typically identified by tail number, but other identifiers can be listed if the damage information applies to all aircraft, or if tail number is not applicable. Additional aircraft tail numbers can be added using AASD Editor.

Once the specific aircraft is selected, the part photo or schematic remains on the screen, but different information is displayed in the right side of the window. This includes the actual flight hours associated with the aircraft or component at the time the damage or repair information was measured. Other information, which can be displayed, includes equivalent flight hours, the number of flight cycles and age of the aircraft (or component) at the time of the measurements.

The next step is to select a damage "Feature" associated with the specific aircraft from the pull down list. Features cover fatigue, corrosion or repair information. The user can also click on the part diagram at the location of the feature of interest to access the data. The location of the features within the part should typically be highlighted in the part diagram. Additional features can be added using AASD Editor.

Each type of feature has corresponding applicable parameters. For example, fatigue is characterized by hole number (or other hole identifier) if any, the hole diameter (if a

hole is associated with the crack), and part thickness. Also included with fatigue are the crack clock position and the measured dimensions with respect to the schematics describing the feature.

The parameters corresponding to the corrosion feature include the part thickness, surface description (fay, exposed, coating description, etc.) and the total part area. This is followed by a description of the corrosion in terms of corrosion area, and corrosion minimum and maximum depth.

Repair features are described by a maximum of six lines of text and a diagram. The feature information can be viewed on a case by case basis. However, users may wish to access groups of data. For example, a user may want to compare the same type of crack in different aircraft, or different corrosion locations on the same aircraft part. Clicking on the "Plot" button permits the user to perform these operations.

The window entitled "Data Analysis" lets the user select what parameters and sample data population he/she wishes to plot. After clicking on the "Plot" button, the data is then plotted using Excel. Excel presents the data in three sheets. The first ("Data") contains the tabulated data corresponding to the parameters requested. This sheet also includes the tail numbers associated with each data pair and the reference from which the data was obtained. The second sheet ("AASD Plot") displays the x-y plot. Finally, the third sheet ("Internal") contains the data used to generate the curves.

The "Data Analysis" window also lets users see plots of the "Material Properties" (da/dN vs. ΔK) or "Spectrum" tables by clicking on the respective buttons. Excel presents the material data in three sheets. The first ("Data") contains the tabulated data, the second ("Material") displays the curves, and the third ("Internal") contains the data and parameters used to generate the curves. The spectrum data is presented in Excel as a simple table. File formats are described in Section 3.4.

3.2 AASD Editor Operation

As mentioned earlier, the database has been organized in a hierarchical format, which allows a user to go from the aircraft down to the specific damage feature information. New data needs to be entered following that order, when using the AASD Editor. For example, if the data corresponds to a new aircraft, then the aircraft type information should be entered first, followed by zone and part data. Specific aircraft information and feature data (for fatigue, corrosion and/or repair) are the final inputs.

After the AASD Editor is accessed, the main window containing different buttons is activated. These buttons bring up each of the forms for entering or modifying data in the following categories: aircraft type, zone, part, specific aircraft (tail number) and feature.

The "Aircraft Type" form lets a user specify an aircraft type from the pull down list or by typing a new aircraft type. The user can then enter the photo name box by clicking into it or by tabbing. An aircraft type photo or schematic file name can then be typed or selected from a list accessed by clicking the "Browse" button. Clicking the "Browse" button takes the user to the "Select Picture" window which displays a scrolling list of picture files contained in the database "Images" directory. Clicking on a file name and on "OK" takes the user back to the "Aircraft Type" form with the selected photo name file. New photos or schematics need to be stored in the designated directory and must be windows bitmaps (*.bmp).

Finally, the user can "Add or Update Aircraft Type" or "Delete Aircraft Type" by clicking on the appropriate button. The form can also be exited by clicking on "Exit".

Once in the "Zones" form, the user selects an aircraft type from the pull down list. The user can tab or click into the zone name box and enter a new zone name. Existing names can be selected from the pull down menu.

The user can enter the photo name box by clicking into it or by tabbing. A zone photo or schematic file name can then be typed or selected from a list accessed by clicking the "Browse" button. Clicking the "Browse" button takes the user to the "Select Picture" window which displays a scrolling list of picture files contained in the database "Images" directory. Clicking on a file name and on "OK" takes the user back to the "Zones" form with the selected photo name file. New photos or schematics need to be stored in the designated directory and must be windows bitmaps (*.bmp).

The next step is to specify the location on the "Aircraft Type" picture where the zone is centered. This is needed so aircraft zones can be selected by clicking within the aircraft type picture at the appropriate zone locations. The location is specified in terms of x percent across and y percent down the aircraft picture. For example, if the zone is in the center of the aircraft picture the user enters 50 (x percent across from the left edge of the aircraft picture) and 50 (y percent down from the top edge of the aircraft picture).

Finally, the user can "Add or Update Zone" or "Delete Zone" by clicking on the appropriate button. The form can also be exited by clicking on "Exit".

Once in the "Update a Part" form, the user selects an aircraft type from the pull down list. The user can tab or click into the zone name box and select a zone associated with the part from the pull down list. Next, the user can tab or click into the part name box and enter a new part name. Existing names can be selected from the pull down menu. The part number and the part section number (if applicable or available) are then typed in the respective box.

After typing the Part Material in the appropriate box, the user can enter a Material File containing material data needed for durability and damage tolerance analysis. This can be a da/dN vs. Delta K data, for example. Existing files can be selected from a list accessed by clicking the "Browse" button. Clicking the "Browse" button takes the user to the "Select Material File" window that displays a scrolling list of files contained in the database "Material" directory. Clicking on a file name and on "OK" takes the user back to the "Update a Part" form with the selected material filename.

The user can enter the photo name box by clicking into it or by tabbing. A part photo or schematic file name can then be typed or selected from a list accessed by clicking the "Browse" button. Clicking the "Browse" button takes the user to the "Select Picture" window which displays a scrolling list of picture files contained in the database "Images" directory. Clicking on a file name and on "OK" takes the user back to the "Update a Part" form with the selected photo name file. New photos or schematics need to be stored in the designated directory and must be windows bitmaps (*.bmp).

The next step is to specify the location on the "Aircraft Zone" picture where the part is centered. This is needed so parts can be selected by clicking within the aircraft zone picture at the appropriate part locations. The location is specified in terms of x percent across and y percent down the zone picture. For example, if the zone picture is 4 inches wide and the part is 1 inch for the left edge of the zone picture, the user enters 25 for "x percent across picture". Likewise, if the zone picture is 6 inches tall and the part is 2 inches for the top edge of the zone picture, the user enters 33 for "y percent down picture".

Finally, the user can "Add or Update Part" or "Delete Part" by clicking on the appropriate button. The form can also be exited by clicking on "Exit".

Once in the "Specific Aircraft" form, the user selects an aircraft type from the pull down list. The user can tab or click into the "Aircraft Tail Number" box and type in a number or select one from the pull down list. Next, the user can tab or click into the "Actual Flight Hours" box and enter a value. This should represent the flight hours associated with the aircraft or component at the time the damage or repair information was measured.

If available, the equivalent flight hours for the aircraft or component can be entered in the next box. Other information that can be entered in the remaining boxes includes the number of flight cycles and age of the aircraft (or component) at the time the damage or repair information was measured.

Finally, the user can "Add or Update Specific Aircraft" or "Delete Specific Aircraft" by clicking on the appropriate button. The form can also be exited by clicking on "Exit".

In the "Feature" form, the user first selects an aircraft type from the pull down list. The user can tab or click into the "Part Name" and "Tail Number" boxes and enter new information or make selections from the pull down lists. Tabbing or clicking into the next box permits the user to enter a new feature name or select from existing features.

Three types of features can be specified in the next box: corrosion, fatigue or repair. Selection of a particular type by the user activates parameter entry boxes corresponding to that feature type. However, before entering detailed parametric information associated with the feature, the user should enter the "Source Reference" information describing where the data was obtained. The next series of boxes can be used by the user to enter the feature description. These boxes are accessed by tabbing or clicking.

In the case of fatigue features the user can enter the hole number (or other hole identifier) if any, the hole diameter (if a hole is associated with the crack), and part thickness. A hole diameter of "0" indicates that no hole is present. Next, the user specifies a crack clock position with respect to the schematics describing the feature. For example, 12 (o'clock) represents a crack propagating vertically and up. This information is useful in describing how the crack is growing with respect to the load direction. This is followed by the measured crack dimensions. A single crack dimension is typically associated with a through the thickness crack. Part through cracks are represented by two dimensions, "a" and "c" in AFGROW nomenclature (Figure 3-2).

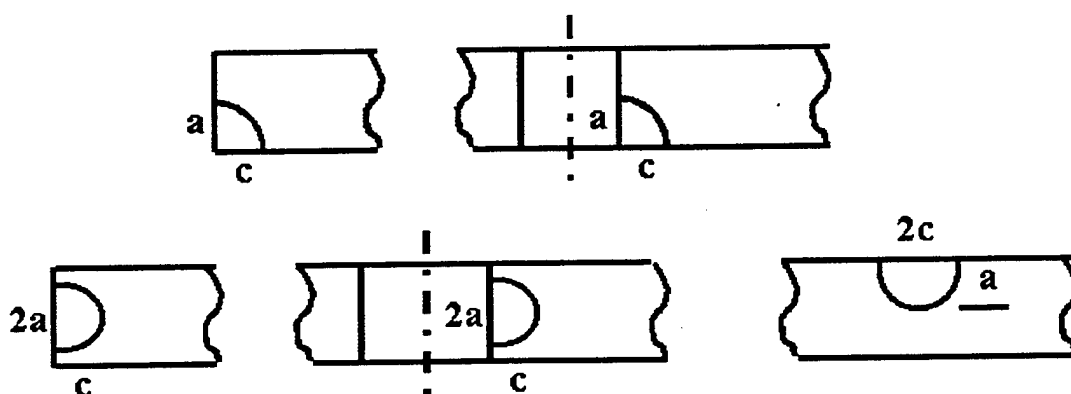


Figure 3-2 – AFGROW Crack Dimension Nomenclature

The last parameter used for fatigue features is the "Crack Geometry", which the user selects from a pull down list. The nomenclature used in this list is compatible with the AFGROW list of crack models. The name selected for a particular crack geometry should be compatible with the parameter values entered for the feature. For example, a "Single Corner Crack at Hole" should have two crack dimensions given.

The parameters corresponding to the corrosion feature include the part thickness, surface description (fay, exposed, coating description, etc.) and the total part area. This is followed by a description of the corrosion in terms of corrosion area, and corrosion minimum and maximum depth.

Repair features are described by a maximum of six lines of text and a diagram.

After entering the feature description, the user can enter a "Spectrum File Name" containing the load or stress history (typically associated with fatigue). Existing files can be selected from a list accessed by clicking the "Browse" button. Clicking the "Browse" button takes the user to the "Select Spectrum File" window that displays a scrolling list of files contained in the database "Spectrum" directory. Clicking on a file name and on "OK" takes the user back to the "Features" form with the selected spectrum filename.

The user can enter the "Photo File Name" box by clicking into it or by tabbing. A feature photo or schematic file name can then be typed or selected from a list accessed by clicking the "Browse" button. Clicking the "Browse" button takes the user to the "Select Picture" window which displays a scrolling list of picture files contained in the database "Images" directory. Clicking on a file name and on "OK" takes the user back to the "Features" form with the selected photo name file. New photos or schematics need to be stored in the designated directory and must be windows bitmaps (*.bmp).

The next step is to specify the location on the "Aircraft Part" picture where the feature is centered. This is needed so features can be selected by clicking within the aircraft part picture at the appropriate locations. The location is specified in terms of x percent across and y percent down the part picture. For example, if the part picture is 4 inches wide and the feature is 1 inch from the left edge of the part picture, the user enters 25 for "x percent across picture". Likewise, if the part picture is 6 inches tall and the feature is 2 inches from the top edge of the part picture, the user enters 33 for "y percent down picture".

Finally, the user can "Add or Update Feature" or "Delete Feature" by clicking on the appropriate button. The form can also be exited by clicking on "Exit".

3.3 Interaction with AFGROW

AASD is designed to permit transfer of data into AFGROW for analysis. Once a set of data is selected in AASD, clicking the "Copy" button copies the appropriate data for AFGROW utilization. Three types of data can be copied: material data files, geometrical description of the part and the fatigue crack, and load spectrum. The material data is typically in the form of a da/dN vs. stress intensity factor curve. The geometric data covers the pertinent part dimensions of thickness, width, and hole diameter needed for the analysis, and also includes crack dimensions. The load spectrum describes the load history. Within AFGROW, data is captured by selecting "AASD" under "tools", and then clicking "paste". The AASD data is then displayed under "AASD to AFGROW Conversion Wizard" [1-1].

3.4 AASD Files and Folders

After installation of AASD several folders are created containing different information. The main AASD folder contains three folders and the executable files associated with AASD software operation. The AASD data editor, for example, is called "upaasd". This program, included in the AASD software installation program, manipulates the relational database currently implemented in Microsoft Access. The actual database file is Aasd.mdb.

The first folder is the "Images" folder containing all the figures, drawings and photographs associated with the data in AASD. These images are stored as ".bmp" files and their names must match the names recorded in the database. The second folder is the "Material" folder containing the da/dN files. These files have the following format:

Number of curves
Title line
"Log of Delta K (ksi sqrt(in))"
"da/dN (in./cycle)"
R value for the first curve
Number of data points
delta K,da/dN
.
.
.
R value for the second curve
Number of data points
etc.

The third folder is entitled "Spectrum" and contains the load history files. The spectrum file format is:

Number of title lines
Title line
.
.
.
"Peak"
"Valley"
"Number of Cycles"
"Load Level"
"Cycles"
Number of data points
Peak,Valley,Number of Cycles
.
.
.

4. Conclusions

Aging Aircraft Structural Database (AASD) was developed to store detailed descriptions of fatigue, corrosion and associated repairs in USAF aircraft. This data will facilitate the development and verification of structural integrity analysis tools needed to model actual damage observed. AASD is also capable of transferring data to the AFGROW crack growth software for analysis. As each structural analysis is completed, AASD can be used to store photographs and information describing the problems solved. This library of analysis cases can be a depository of case histories and an important source of lessons learned.

Other databases are under development or in use at USAF Air Logistics Centers. However, AASD is not meant to compete with these systems, which contain a level of detail required for maintenance record keeping and fleet tracking. AASD only stores data needed for structural integrity analysis. ALC databases are typically associated with specific aircraft, while AASD provides a location for storing data for military aircraft throughout the fleet. Because of security reasons, maintenance data in the other systems has limited access. AASD is intended for wide government and industry distribution.

Representative data has been included in the AASD for the following aircraft: C-130, EC-135, C-141, and F-15. The purpose of including this data in the first version of AASD is to illustrate a wide variety of fatigue, corrosion and repair cases within the aging fleet. Also, the data serves as an example of how data can be stored in the database for a wide variety of aircraft.

4.1 Other Sources of Data

AASD includes some of the EC-135 data generated for Oklahoma City-ALC. However, additional data for C/KC-135 as well as for the B-52, for example, has been generated by OC-ALC through its corrosion program [4.1-1]. The data search did not cover Ogden-ALC. However, because OO-ALC is responsible for maintenance for aircraft such as the F-16 [4.1-2], additional data is available at this ALC. The F-16 has experienced corrosion in many 2xxx and 7xxx series aluminum components [4.1-3], as well as fatigue cracking in several key locations [4.1-4 thru 7]. San Antonio Air Logistics Center also has fatigue data for such aircraft as the T-38 [4.1-8].

Although not covered under this program, commercial aircraft offer a potential source of data. However, Reference [4.1-9] indicates that maintenance documentation is limited in the area of corrosion fatigue and records are usually not complete. According to the reference, airframe manufacturers are prevented from exposing their data by proprietary restrictions. Nevertheless, the Federal Aviation Administration [4.1-10] and Sandia National Laboratories [4.1-11] are potential sources of data.

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